Spring 13

Extron Mid-Semester Progress Report

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Executive Summary

Our senior design project is to research the interactions between TCP and MPEG-DASH. Our sponsors are Extron Electronics - via Dr. Mike Izquierdo – Dr. Harry Perros of NCSU. Our project is based on the work of graduate students at Alpen-Adria-Universität Klagenfurt, a College of Education Studies in Austria. We were tasked with using their working model of HTTP Adaptive Streaming – a project named ITEC DASH – to create a testbed for testing adaptive streaming over HTTP.

MPEG-DASH is a dynamic adaptive protocol for streaming encoded video over the Internet. This means that the video will play at the best quality it can with little to no buffering time, given the available bandwidth. If the available bandwidth increases, the video stream will switch to a higher quality, and if the available bandwidth decreases, the video stream will switch to a lower quality in order to keep the video playing without needing to pause for buffering. A server stores a video manifest along with all the video files for each video. If the user wishes to watch a movie, then they put the location of the video's manifest file into the VLC player. The VLC player will then determine which video stream to use, and constantly monitor the buffer, input bit-rate, and the available bandwidth.

Phase one began with studying several research publications from this team and on the topic of adaptive streaming, after which we created a plan of action, compiled a list of hardware we'd need, and assembled and configured our testbed, completing phase one of our project. Our test bed includes four desktop computers, each with a specialized role to play within the network. At the center of our network is a switch that allows us to branch the network across two subnets. One of the subnets houses the HTTP Server and the Network Emulator while the other includes the Client and Traffic Generator. This setup allows us to emulate a full network environment through which to stream video. The majority of our challenges during this first phase revolved around creating a specific plan of action, building the network configuration from the ground up, and creating several scripts to maintain the network configuration via IP tables.

Phase two is the software equivalent of phase 1 and the majority of it included creating the testbed environment for streaming. This began with finding a decoder that worked, creating a connection from the server to the client through the network, finding a decoder that worked, and finally finding a workaround for our lack of working encoder. By far the most challenging aspects of this phase were the encoder and decoder. The decoder listed in the ITEC DASH project was unable to properly compile, while the encoder that we agreed upon – VLC – was unable to stream resolutions high enough to judge changes in visual fidelity. We managed to end Phase two by creating scripts that create a workaround for the decoder, and

configuring our network and VLC to finally allow the full range of video streaming quality.

Our next steps include finalizing all setup and user guide documentation for our testbed, creating our test plan, and growing our video library. A majority of the time will be spent creating the test plan as a team due to the fact that there are many different ways we can approach the TCP and MPEG-DASH interaction. It is also especially important that the team, as a whole, understands and agrees on the test plan before moving forward so that we can focus on exploring the test results rather than repeating tests due to confusion. We plan to complete these tasks by March 1, 2013 as we head into Spring Break. When we return we will begin our testing and start analyzing the data.

Introduction

Sponsor Background

Extron Electronics is a large manufacturer of professional Audio/Video hardware and software that was established in 1983. Their products are used to create Audio-Visual presentation systems for universities, presentation centers, boardrooms, and other applications. Extron has a number of offices around the globe in order to provide full-service to their customers world wide, and their headquarters is located in Anaheim, CA.

Problem Statement

The goal of this project is to create a streaming media testbed using open source software in order to study the study the performance characteristics and possible interactions between the adaptive mechanism and the standard protocol stacks, as described in the recent paper "Dynamic Adaptive Streaming over HTTP Dataset", Proceedings of the Second ACM Multimedia Systems Conference (MMSys), pp 89-94 (2012). Operation of the testbed should be demonstrated by reproducing experiments described in the above paper.

A stretch goal is to explore the effect of TCP interaction on the congestion control mechanism of HTTP Adaptive.

Impact of Research

Our research will illuminate flaws and areas of interest in the cutting edge adaptive streaming over HTTP technology. Furthermore, by creating a documentation of our HTTP streaming testbed setup based entirely on open source software, we are paving the way for future research into the area and dramatically reducing the learning curve and cost to entry for this technology. Lastly, our results will provide insightful information for our sponsor, Extron Electronics, that will enable them to include MPEG-DASH support in their product line. Through MPEG-DASH products Extron would be able to provide to the market streaming video appliances that would work with a wide range of devices.

Challenges

Phase 1

Phase 1 challenges revolved around creating a plan of action and configuring the network for a two-subnet model. The MPEG-DASH format is in its infancy, which means there are many open questions and many unexplored avenues of

investigation. To overcome the challenge of choosing specific questions to investigate and one avenue of attacking the problem, we spent a couple of weeks studying research on the subject and meeting with our sponsor. Eventually, we were able to narrow our focus and agree on a plan of action. The challenge of setting up the network was that of a learning curve; our resident network experts had to spend a week familiarizing themselves with subnets and IP tables before finally arriving at a stable, self-maintaining network model.

Phase 2

Our second phase involved problems of the more technical nature. This phase dealt with setting up all the various links between server and client that allowed for MPEG-DASH streaming. This was troublesome on multiple fronts: the ITEC DASH encoder was unable to compile, the HTTP server needed videos that were unable to be pulled with ftp, and the decoder refused to play video above a very low bandwidth. We began with the encoder problems: after spending several days attempting to configure and correct its flaws, we decided to grab pre-generated videos from ITEC DASH for the sake of looming deadlines. These videos, however, were ftp-locked. To work around this, one of our team members created a script that would batch pull huge amounts of files directly from the ITEC site and properly organize them on the server.

Finally, once all the pieces were working, we began to work on our last challenge: the fact that our decoder was not accepting video higher than 500kbits/s; eight times lower than what it should be requesting (in other words, terrible 240p instead of high-definition 1080p). After many hours spent attempting to isolate and solve this problem, we finally were able to configure VLC in such a way that it would accept all ranges of input resolution, thus solving the problem.

Phase 3

Our current challenge is to identify targets of investigative interest; that is, we need to meet with our sponsor and create a plan for the use of our testbed. Our primary concerns at the moment are: Which questions should we be asking, how should we answer these questions, and how do these results relate to the bigger picture of MPEG-DASH? In the following week, we will work with our sponsor in an attempt to answer each of these questions by Spring Break so that we can return and begin testing full-steam.

Background Research

Related Research

This new area of research has sparked lot of interest across the globe. Below are some of the papers we have studied to gain a better understanding of our topic.

- "The MPEG-DASH Standard for Multimedia Streaming Over the Internet" by Anthony Vetro, an overview of the MPEG-DASH format including a description of use, segmentation, and scope.
- "Adaptive HTTP Streaming and HTML5" by Mark Watson, a look at how Netflix implements an adaptive streaming model for tens of thousands of users.
- "Will HTTP Adaptive Streaming Become the Domain Mode of Video Delivery in Cable Networks" by Michael Adams, describing how adaptive streaming works and detailing several advantages over traditional cable network structures.
- "An Experimental Evaluation of Rate-Adaptive Algorithms in Adaptive Streaming over HTTP" by Akhshabi, Began, and Dovrolis. This paper was incredibly helpful in setting up our methodology; ours is modeled on the same general approach, despite their using Microsoft Silverlight where we use VLC. As we begin preparing for Phase 3, we will also re-reference this paper for ideas on data analysis.
- "Dynamic Adaptive Streaming over HTTP – Design Principles and Standards" by Thomas Stockhammer, a paper that detailed the advantages of HTTP streaming as well as the intricacies of 3GP-DASH, and describe the future of the MPEG-DASH project.

Work Completed by Others

For our project, we have been asked to replicate an experiment conducted by Lederer, Müller, and Timmerer of Austria. Their research was documented in a paper, "Dynamic Adaptive Streaming over HTTP Datasets," including how they set up their video files, setup of their system, testing, and data analyzing.

Methodology

Process Flow

To begin, we broke our project into three phases listed below:

Phase 1

Constructing a multi-subnet testbed that will be able to test the interactions of MPEG-DASH and TCP.

Phase 2

Create a working video stream from Server over the Network Emulator to the Client using MPEG-DASH.

Phase 3

Analyze and investigate MPEG-DASH format over HTTP; look for interesting behavior using Network Emulator to shape traffic conditions and look for any interesting behavior in the streaming video while using the Traffic Generator to flood the network with TCP packets.

Action Steps

Below are the phases and their respective requirements.

Phase 1

- Determine hardware necessary to complete test bed
- Once accessible, create a simple testbed with a Server, Network Emulator, and Client that can be adapted to the desired test environment
    - Create routing tables to allow each element to communicate with the proper components
- Download all necessary software
- Create a document with setup instructions so that the testbed can be replicated

Phase 2

- Download all files necessary to start streaming videos.
- Configure the NetworkEmulator to a point where we can control the bandwidth, time delay, and packet loss on the connection from the server to the client

- Find and determine proper filters to apply to WireShark to capture the necessary packets.
- Create any and all, if applicable, scripts that will be used for setup and/or testing of the network.
- Create a Test ("Experiment") Plan of what the different cases are that we will investigate with MPEG-DASH. (i.e. Drop bandwidth in intervals, simulate a network disconnection where we complete drop the bandwidth for a certain amount of time and then bring it back, etc.)
- Begin to stream video using MPEG-DASH with WireShark and WANem.
- Begin to test the Traffic Generator for TCP packet creation

Phase 3

- Run Experiments from the Test Plan
- Start analyzing the MPEG-DASH packets and video quality:
    - Keeping each of the test groups together and organized
    - Map results against each other to find R trends.
    - Start creating visuals to help with explaining the results
- Add test cases to the plan and experimentation in areas that are found to be interesting.
- If desired, add any changes to the testbed configuration

Resources Needed

There are many resources needed to complete this project and at this point in time, we have acquired all necessary resources. To help keep it organized, we have divided it into two different types of resources, hardware and software.

Hardware

- 4 desktop computers
    - Each with keyboard, mouse, and monitor
    - Ubuntu installed on 4 of them, while the Network Emulator boots into a simplified version of Knopix
    - The Server and Network Emulator each have 2 NICs, while the other two computers have only 1 NIC
- 5 Ethernet cables
- 1 5-port switch

Software

- Ubuntu 12.10
- Apache
- WireShark
- PackETH

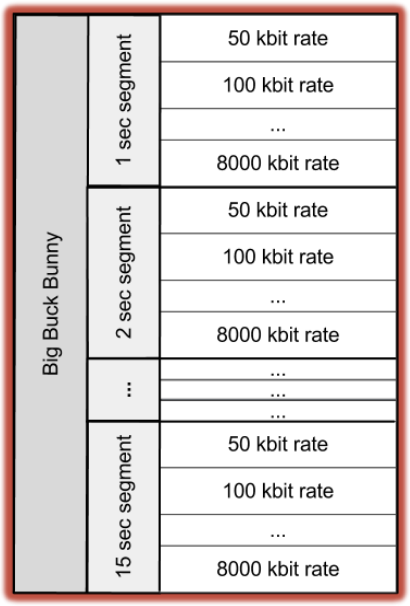
- WANem
- VLC
- Cisco WebConnect
    - For VPN remote access
- Built in VNC client

Experiment Setup

Our testbed includes four desktop computers that act as their own part in the testbed; the HTTP Server, Network Emulator, Traffic Generator, and the Client.

HTTP Server

The HTTP Server is the only machine that is directly connected to the Internet and to the Network Emulator, which is then connected to the five-port switch; the other two machines are directly connected to the switch. This component will be used to house all of our video files and their corresponding manifests. The video files are full-length movies that are broken into different segment lengths and different bit-rates. The videos start out has full-length .mp4 files that are put through an encoder that breaks the video into multiple uniform-length segments. The encoder will also generate many copies of different bit-rate resolutions of all the segments. For example, the following table shows a basic break down of the file structure that is generated by the encoder.



Big Buck Bunny Files Organization: *This diagram helps represent how the big buck bunny file system is organized.*

Network Emulator

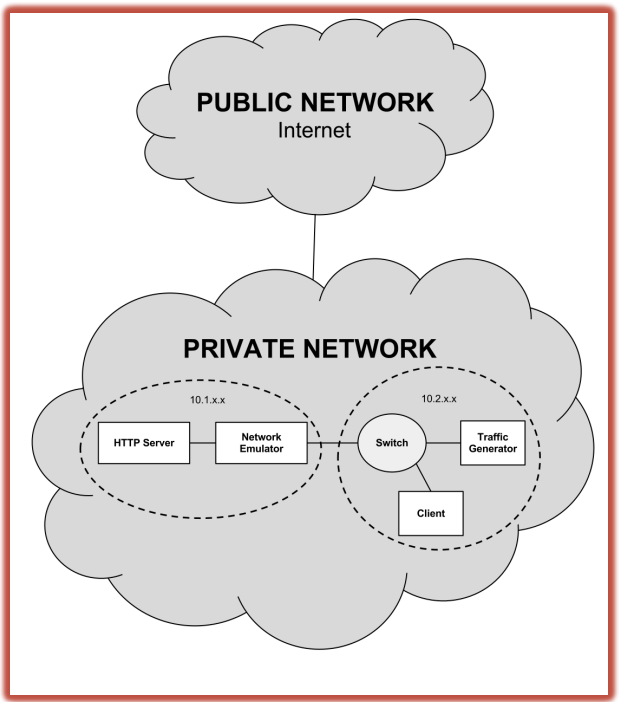
The Network Emulator connects the five-port switch to the HTTP server and acts as bottleneck for the MPEG-DASH streaming. This is a key component for our research because it allows us to simulate different bandwidths, time delays, and percentage packet loss in different sequences over time. We use a lightweight version of Knopix, which is controlled via a program called WANem, to change all of these settings.

Traffic Generator

The Traffic Generator is connected to the network via the five-port switch and will be used later in our research. Eventually it will be used to generate TCP traffic across the network using a program called PackETH.

Client

The Client is also connected to the network via the five-port switch. This component is used to view streaming MPEG-DASH video that is coming through the network. The Client has the nightly build of VLC installed so that it is able to successfully stream the MPEG-DASH video as well as display its current statistics for incoming bit rate of the video stream, which our team will capture and analyze.



Network Diagram: *This is a high level diagram of our network.*

Testing

Software/Hardware Testing

Our project's first and second phases have no components that can be tested. The testing for this project rests heavily within the third phase but some testing is needed to ensure our testbed is functioning properly. The following tests are performed to ensure such a case.

Testbed Tests			
Test Case	**Steps**	**Expected Results**	**Actual Results**
WireShark	1. Open Wireshark 2. Select "Show the capture options..." 3. Select the interface you want to capture on. On our HTTP server it is ETH1 that goes to the private networks. 4. Double click the interface to bring up the "Edit Interface Settings" window. 5. Select "Capture Filter" scroll through the list and select the "GETs" filter. This filter was made by us, the actual filter data is "(port 80 and tcp[((tcp[12:1] & 0xf0) >> 2):4] = 0x47455420) and host 10.2.1.2". This tells it to filter GET messages from a specific host. 6. Click "OK" to close out the settings menus. 7. On the "Capture Options" menu select "Start". Wireshark will now be capturing packets.	As long as the video is running on the client, one will see a continus stream on 'GET' packets showing on the screen	
Network Setup Test (Every Machine)	1. Open a Terminal 2. Input the following commands: ping -c 1 10.1.1.1 ping -c 1 10.1.1.2 ping -c 1 10.2.1.1 ping -c 1 10.2.1.2 ping -c 1 10.2.1.3 ping -c 1 www.google.com	team20@Client:~$ ping -c 1 10.1.1.1 PING 10.1.1.1 (10.1.1.1) 56(84) bytes of data. 64 bytes from 10.1.1.1: icmp_req=1 ttl=63 time=0.299 ms --- 10.1.1.1 ping statistics --- 1 packets transmitted, 1 received, 0% packet loss, time 0ms rtt min/avg/max/mdev = 0.299/0.299/0.299/0.000 ms	

Testbed Test: This is a table of all tests that need to be completed to ensure that our testbed is functioning as intended.

Performance Testing

During the third phase, our project will incorporate various tests to investigate standard network effects – emulated with techniques such as bandwidth capping, packet flooding, packet corruption, and so on – on video streaming over HTTP. Although we are in the early stage of planning these tests, our dependent variable will generally always be video quality. This will be analyzed in three different ways: display resolution, input bit rate, and using packet sniffing programs (e.g. WireShark) to detect which GET statements the decoder is sending to the server. As we move further into Phase 3, we will work with our Sponsor to identify important areas to research and create a plan with which to do so. As of right now, we plan to focus our test on VLC performance versus YouTube performance with these variables.

Performance Testing

Experiment	Independent Variable	Dependent Variable
Experiment 1	Bandwidth cap	Input Bandwidth
		GET Requests
		Latency
Experiment 2	Buffer size	Input Bandwidth
Experiment 3	Packet flooding	Input Bandwidth
Experiment 4	Segment Size	Input Bandwidth
	Buffer Size	Input Quality
		GET Requests

Performance Testing: This is a table containing all areas that we plan to run experiments in. It is a rough draft and we plan to expand on it more after the break with our sponsor and Dr. Perros.

The tools we will be using to capture this data include VLC's CLI for input bandwidth, WireShark and WANEm for latency, and WireShark for GET requests. We will use R for analysis of our data.

We will be expanding on these experiments to include more of a detailed plan as we continue to work with our sponsor and Dr. Perros.

Results and Discussion

Our project has no results or necessary discussion for Phases 1 and 2, but Phase 3 is entirely composed of testing, results, and discussion. We anticipate using WireShark to collect data on a number of areas of interest (to be defined with our sponsor before Spring Break) and R for statistical analysis of data. Our results will comprise mainly the interaction between various independent variables, such as bandwidth, packet corruption, network flood, and buffer sizes, and dependent variables such as decoded resolution, input bit rate, and buffer times. The results along with our analysis will be discussed in our final report.

Conclusion

In conclusion, it is safe to report that our team is on track and well on our way towards conducting a meaningful investigation into MPEG-DASH that will benefit the entire adaptive-streaming community. With only one alteration to our original plan, changing our design from using an encoder to using pre-generated content, we have met and exceeded all goals of Phase 1. At this point, it is possible for another team to use our documentation and methods to similarly create a testbed, thus preparing the way for many future research projects of this nature. During our third and final phase where we will be testing for MPEG-DASH on various network emulations for interesting results, we hope to find data that will shed light on the stability of adaptive streaming over HTTP.

Suggestions for Future Teams

The most important thing that we can suggest for future teams is to stay away from Virtual Machines entirely. Virtual Machines are troublesome as remote computers and hellish as networked boxes. Setting up the testbed using physical machines is somewhat complicated - there are some specific, albeit basic, routing and networking construction - but far easier than doing so on a VM. Furthermore, with Virtual Machines it is very hard to precisely control your bandwidth, given the remote nature of each machine - on a small physical network, however, you can control it to such a fine level that you can monitor each packet sent and received.

Next, we suggest using pre-generated test cases and focusing on the decoder aspect, as opposed to the encoder. The decoder is more important to set up quickly because it makes or breaks the project, whereas there are many alternatives to any given encoder (including, as mentioned, pre-generated content).

Lastly, we suggest familiarizing yourself with both Unix and VLC (or decoder of choice) configuration settings. These tools will need to be frequently used, and a good-to-expert knowledge of both will greatly improve the project chances of success.

Task Plan

Team 20 Task Plan			
Item	**Owner**	**Due Date**	**Status**
Phase 1			
• Determine hardware necessary to complete testbed	All	18-Jan	Complete
• Create a simple testbed	All	28-Jan	Complete
• Create routing tables	Corey, Chris	1-Feb	Complete
• Downloadbase software software	Natalie, Corey, Jean	1-Feb	Complete
• Create setup documentation	Natalie, Jean	1-Feb	Complete
• OPR1	Corey	28-Jan	Complete
Phase 2			
• Download software for streaming	Corey, Natalie	6-Feb	Complete
• Setup and configure Network Emulator	Chris	15-Feb	Complete
• Troubleshoot VLC bugs	Corey, Chris	15-Feb	Complete
• Download Encoder and Decoders	Jean	8-Feb	Complete
• Troubleshoot Encoder	Jean	15-Feb	Postponed to Phase 3
• Setup all necessary filters on WireShark	Chris, Natalie	15-Feb	Complete
• Create scripts for testbed setup	Corey		Complete
• Create script to mass download files	Jean	20-Feb	Complete
• OPR2	Jean	25-Feb	Complete
• Create Written Progress Report	Natalie	19-Feb	Complete
• Edit Written Progress Report	All	1-Mar	Complete
• Create Experiment Test Plan	All	12-Mar	In Progress
Phase 3 (will divide work at start of this phase)			
• Run experiments	All	20-Mar	Not Started
• Anaylze data	All	27-Mar	Not Started
• Create visual of results	All	19-Apr	Not Started
• Create any extra tests that may be needed	All	1-Apr	Not Started
• Run any extra tests that may be needed	All	12-Apr	Not Started
• Analyze any extra tests that may be needed	All	19-Apr	Not Started
• Troubleshoot Encoder (if time allows)	All	8-May	Continued
• OPR3	Chris, Natalie	25-Mar	Not Started
• Poster for Posters and Pies	All	22-Apr	Not Started

Task Plan: This is a table of our ongoing task plan.

Team Contact Information			
Name	**Role**	**Email**	**Phone**
Chris Allen	Developer	crallen@ncsu.edu	919.812.2017
Jean de Klerk	Developer	jadekler@ncsu.edu	919.523.8776
Natalie Kerby	QA, Recorder	ndkerby@ncsu.edu	703.409.5010
Corey Melton	Team Lead	cbmelton@ncsu.edu	919.699.2022